Safety, Health and Environment National Authority

INDUSTRY GUIDANCE NOTE

TOPIC: **GUIDANCE TO MACHINERY SAFETY**				Reference Number: **2024/IGN/03**
Approved by: **Acting Director of Compliance and International Division**	Endorsed by: **Chief Executive Officer (CEO)**	Issue date: **08th November 2024**	Expiry date: **None**	Revision No: **0**

TABLE OF CONTENTS

1. INTRODUCTION

The use of machinery has always been used in nearly every industry and for commercial use. The machines help to improve the production efficiency at the workplace. However, using the machinery comes with risks. The moving parts of the machines such as the clamps, presses, and hot surfaces can impose great risk and injuries to the operators. The non-mechanical parts can also bring about a hazard should there be an improper use of the machines and / or faulty.

The occupier of the workplace and employer have a legal duty of care as stated in WSHO, 2009 which as far as reasonably practicable, is to ensure that the safety and health of the workers is not at risk. This includes using the safe use of machinery to be the standard of practice at all workplaces.

Aside from competency training from the operators and individuals, operational precautions are essential for the use of machinery. Following the WSH (General Provisions) Regulations, 2014, relevant protection installations should be introduced to remove and minimise the hazard completely.

2. LEGAL FRAMEWORK

WORKPLACE SAFETY HEALTH ORDER, 2009

The Order stipulates the WSH obligations to be fulfilled as well as the responsibilities of every person at work.

Under the Order, the subsidiary legislation applicable to safe use of machinery includes:

- **WSH (RISK MANAGEMENT) REGULATIONS**
- **WSH (GENERAL PROVISIONS) REGULATIONS;** and

Together, the WSHO, 2009 and its subsidiary legislations spell out the requirements for employers, principals and self-employed persons in all workplaces to:

- Conduct risk assessments (RA) to identify and control WSH risks
- Provide safe work facilities and arrangements for workers
- Ensure safety in machines, equipment, substances used, and work activities carried out
- Provide adequate instruction, information, training, and supervision to workers; and
- Implement risk control measures for dealing with emergencies.

The WSH (General Provisions) Regulations include provisions for protecting workers and employed persons when using machines. Under the law, it is the duty of the occupier of a workplace to ensure that every dangerous part of any machine in the workplace is securely fenced unless it is placed in a safe position; made safe by construction; or other effective means when the dangerous part is in motion or in use.

The law also requires lock-out tag-out (LOTO) procedures to be established and implemented during machine inspection, cleaning, repair, and maintenance. This is because a machine if inadvertently activated or energised, is liable to cause bodily injury to any person at work.

Other relevant regulations include:

WSH (FIRST AID) REGULATIONS

The Regulations stipulate the requirement for every workplace to be provided with a sufficient number of adequately equipped first-aid boxes. It is also compulsory for every person who is appointed a first aider in a workplace to complete the Occupational First Aid Course.

WSH (INCIDENT REPORTING) REGULATIONS

Under the Regulations, it is the duty of the employer or occupier to report any (i) workplace accident leading to fatality or injury, (ii) incidence of occupational disease, or (iii) any dangerous occurrence to the Authority.

3. GLOSSARY OF TERMS AND ABBREVIATIONS

IGN	INDUSTRY GUIDANCE NOTE
WSHO, 2009	Workplace Safety and Health Order, 2009 the primary Law on Workplace Safety and Health in Brunei Darussalam, introduced in 2009 sets the general framework to which all workplaces must comply and has been enforced with effect from 1st August 2013.
WSH (General Provisions), 2014	Workplace Safety and Health (General Provisions) Regulations, 2014. The regulation is the safety standard to which workplaces must comply.
WSH (Risk Management) Regulations, 2014	Workplace Safety and Health (Risk Management) Regulations, 2014. The regulation is the risk management procedure to which every employer must abide.

4. PURPOSE

This Industry Guidance Note (**IGN**) serves as a guidance and reference for any matter pertaining to the use of machinery safety in a workplace as per the WSH (General Provisions) Regulations, 2014 as well as control measures in the WSH (Risk Management) Regulations, 2014.

The regulation aims to provide a consistent provision of machinery safety in the workplace as well as to adhere to the WSH (Risk Management) Regulations, 2014.

In this note, the types of hazards associated with the use of machinery and the machinery themselves are described as well as hierarchy controls depending on the types of machinery.

Machinery hazard revolves around two machinery parts particularly the mechanical moving parts as well as the non-mechanical moving parts.

The mechanical hazards arise from the movement of the mechanical parts with the human body which leads to having contact. The results from this contact can lead to the injuries. The non–mechanical hazards associated with the machine do not come from direct contact with the moving parts but rather, usually come during the usage of the machine or the aftermath of using the machine.

The risks and hazard associated with the mechanical parts can be such as:

1) Entanglement – limbs, hair, clothing.
2) Impact.
3) Contact – Cutting, puncture and friction.
4) Ejection – Particles ejecting from equipment.

The non-mechanical parts relate to the common use of the hazard which includes:

1) Noise
2) Heat
3) Electricity
4) Chemical
5) Ergonomics
6) Fatigue

5. SCOPE

This document provides the safety and health guidelines and precautions under the Workplace Safety and Health (Provisions) Regulations, 2014 as well as some recommendations to establish a good practice of safe use of machinery in the workplace.

6. ROLES & RESPONSIBILITIES

EMPLOYER

- As far as is reasonably practicable ensure that adequate safety measures are taken in respect of any machinery and equipment used by a person at work.

OCCUPIER

- As far as reasonably practicable to ensure that any machinery and equipment are safe and without risks to health to every person within those premises, whether or not that person is at work or is an employee of the occupier.

WSH OFFICER

- Assist the employer or occupier in charge of conducting risk assessment at the workplace which includes the machinery to be used.
- Make recommendations to the employer or occupier.

Manufacturer and suppliers of machinery and equipment.

- It shall be the duty of the manufacturer or supplier as far as reasonably practicable that the following information about the safe use of machinery or equipment is available to any person to whom it is supplied for use at work.
- To ensure that there are precautions to be taken for the proper use and maintenance of machinery or, equipment
- To ensure that the health hazards (if any) associated with the machinery or equipment are available to the person to whom the machinery or equipment is supplied to for use at work.
- To ensure that the information relating to and the results of any test or examination of the machinery or equipment are relevant to its safe use.
- The machinery and equipment are safe and without health risk when properly used.
- The machinery, equipment is tested and examined to be safe.

Persons who erect, install, or modify machinery or equipment and persons in control of machinery for use at work

- It shall be the duty of any person who erects, installs, or modifies any machinery or equipment for use at work as reasonably practicable, that the machinery or equipment is erected, installed or modified so that it is safe for use and without health risk. Note that this shall only apply to Part 1 of the Fifth Schedule of the Workplace, Safety and Health Order, 2009.

7. MECHANICAL HAZARDS

7.1 ENTANGLEMENT

Entanglement may arise in the course of work when part of a worker's body (e.g., hand or foot) or loose items worn by him/ her (e.g., clothing or gloves) come into direct contact with a moving machine part.

In general, entanglement involves:

a) Contact with single rotating surfaces such as couplings, spindles, chucks, leadscrews, mandrels, bars, or any rotating workpiece.
b) Being caught by projection or in gaps such as fan blades, spoked pulleys, chain wheels, gear wheels and flywheels, belt fasteners, projecting the keys, set screws, cotter pins on shafts or slat conveyors.
c) Hands being caught in between counter-rotating parts, for example, gear wheels, rolling mills, mixing rolls and calendars or materials being drawn between two rolls.

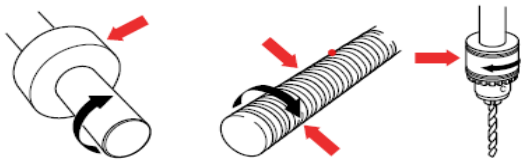

Figure 1: Entanglement by contact with a rotating object

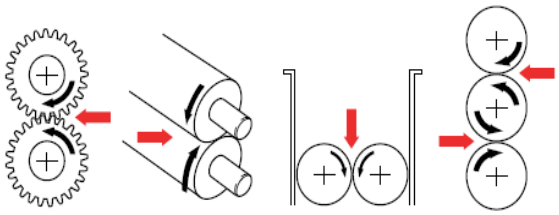

Figure 2: Entanglement from being caught between two rotating objects.

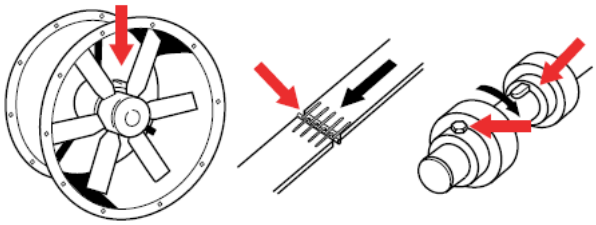

Figure 3: Entanglement caused by being caught by moving objects

(These photos have been taken from WSH Guidelines on Safe Use of Machinery – WSH Council at Singapore)

7.2 CUTTING HAZARDS

Machines used to cut wood, metal, or other materials provide cutting hazards at the site of operation. All types of cutting instruments, milling cutters, circular saws, handsaw blades, rotary knives, disc blades, and the sharp edges of sliding sheets of material are a few examples of cutting hazards. When they come into touch with the body of the worker, machines or instruments with moving cutting parts have the potential to cause significant injury (such as deep cuts or amputations) due to their momentum. When the body part is trapped in place and the worker is unable to move away from the cutting element, the severity is increased. Cutting risks can also arise

when items (such as flying metal or scrap metal) that are released from a machine strike the machine operator.

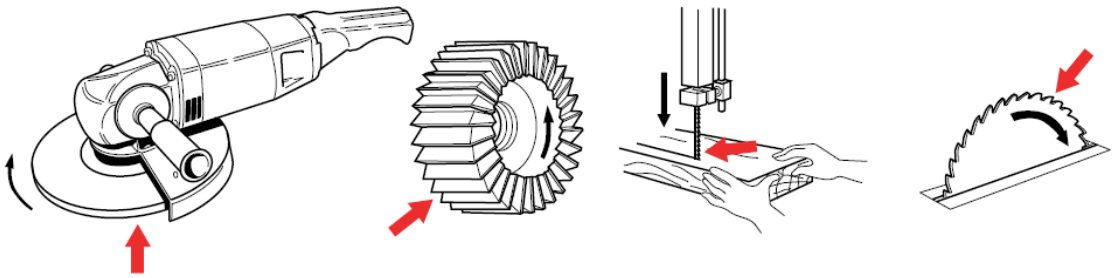

Figure 4: Examples of cutting hazards

(These photos have been taken from WSH Guidelines on Safe Use of Machinery – WSH Council at Singapore)

7.3 CRUSHING HAZARDS

Crushing hazard occurs when a body part is caught:

a) Between the fixed and moving parts of a machine (e.g., between bed and tool of a power press);
b) Between a moving machine part and a fixed structure (e.g, between a machine counterweight and floor); and
c) Between two moving parts of a machine (e.g., between support arms of a scissor lift platform;).

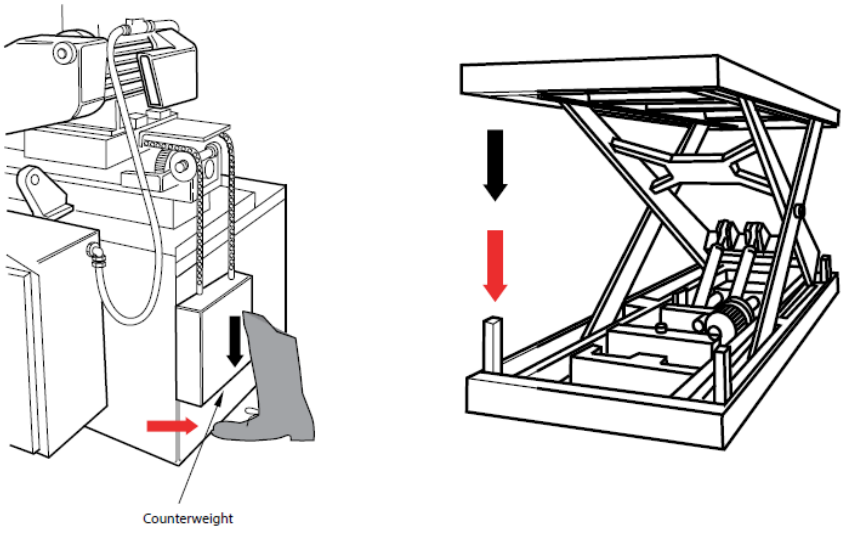

Figure 5: Example of crushing hazards

(These photos have been taken from WSH Guidelines on Safe Use of Machinery – WSH Council at Singapore)

7.4 IMPACT HAZARDS

Impact hazards relate to objects that strike the human body, but do not penetrate it. The severity of an impact hazard depends on the speed, force and inertia of the moving machine part(s), and material(s) being processed during machine operation or upon ejection from the machine. Some examples of impact hazards include being struck by the rotating arm of a robot or being exposed to a high-pressure jet of air or water. Impact hazards often result in serious injury such as abrasion and bruises.

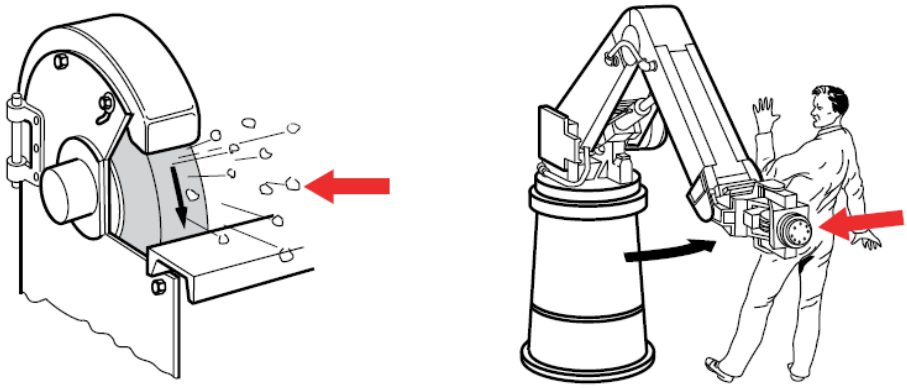

Figure 6: Examples of impact hazards

(These photos are extracted from WSH Guidelines on Safe Use of Machinery – WSH Council at Singapore)

7.5 SHEARING HAZARDS

Parts of machines that move past each other or stationary objects can cause a shear point resulting in a crushing or cutting action. In general, shearing hazards are present:

a) Between two machine parts (e.g., a power press punch and die); and
b) Between a machine and a workpiece (e.g., the transfer mechanism tool of a broaching machine and its workpiece).

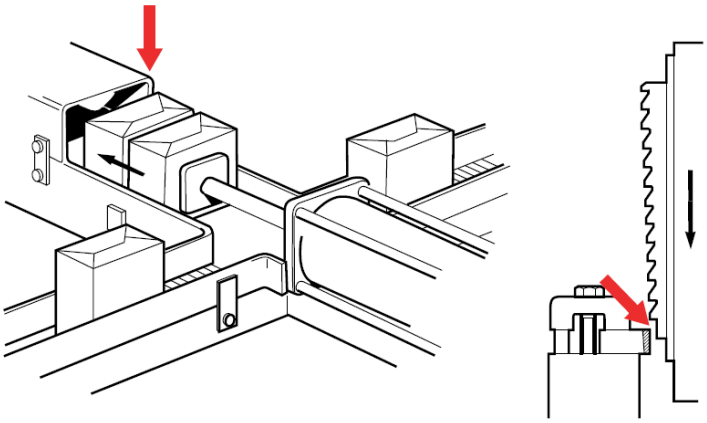

Figure 7: Example of shearing hazards

(These photos have been taken from WSH Guidelines on Safe Use of Machinery – WSH Council at Singapore)

7.6 DRAW IN HAZARDS

Injuries can occur when a body part is drawn in by in-running nip points formed by two counter-rotating parts or between rotating and tangentially moving surfaces.

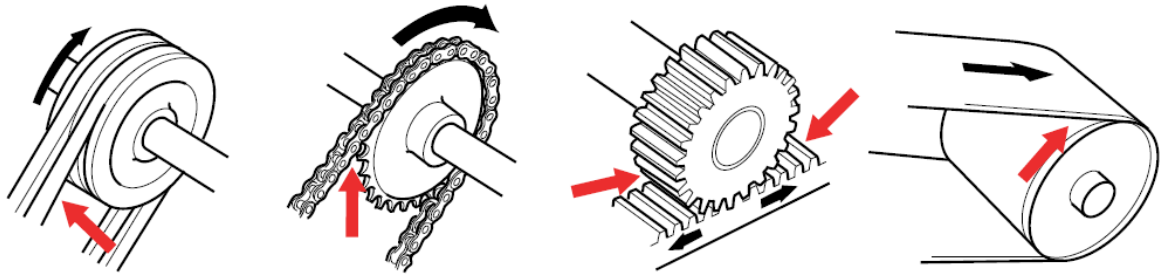

Figure 8: Example of draw-in hazards which includes rotating and tangent moving objects

(These photos have been taken from WSH Guidelines on Safe Use of Machinery – WSH Council at Singapore)

8. NON – MECHANICAL HAZARDS

8.1 ELECTRICITY

The workers can be exposed to electrical hazards during their daily operations for example when the machines or the tools are in use or during electrical installations. The accidents may be due to a failure in the electrical machines, the electronic circuits can get overloaded or short circuit, as well as exposure to a live wire (usually comes

from the worn-out insulation). The electrical machines and equipment must be inspected regularly by a competent person to ensure that they are in good and safe condition. Extreme care should be taken in place where workers come into contact with fluids that are good conductors of electricity. It would be recommended to conduct a continuity test for every electrical installation, during erection and on completion before being put into service, to verify that the Circuit Protective Conductor (CPC) forms a continuous path around the circuit under test.

8.2 CHEMICALS

The workers carrying out the machines may come into contact with the chemicals in their daily activities as the machines rely on the use of chemicals for normal function. Some of the examples include:

a) Electrical generators that require diesel as fuel
b) Equipment with moving parts that require lubricants to ensure smooth operation.
c) Vehicles requiring hydraulic fluids in their braking mechanism.
d) Refrigerators and air conditioners require refrigerants to achieve cooling.
e) Wet etching
f) Machine maintenance that uses cleaning agents

Chemical contact with the skin is possible during various instances for example during cleaning operations, preparation and drainage of machine fluids, handling of work pieces and changing and setting of tools.

Inhalation can also be another way of getting exposure. This happens when one is working on a machine that generates chemical fumes and has no proper ventilation or working area. Prolonged exposures can lead to skin disorders and poor respiratory health.

Occupational exposure by ingestion can also happen but is less common due to the employees not washing their hands properly before drinking and eating and if the harmful chemical is swallowed, extensive damage to the mouth, gullet and stomach can happen.

In the metalworking industry, machine fluids are necessary to reduce the friction and heat generated between the tool and metal. The use of the chemical fluid helps to improve and prolong the life of the cutting tool.

8.3 ERGONOMIC RISK

When using the machines, there are ergonomic health risks that can lead to sprains and strains on one's back and other parts. Workplace factors associated with musculoskeletal disorders include the following:

AWKWARD POSTURES

- The human body functions best in natural postures. Prolonged awkward body postures increase the stress on muscles and ligaments, leading to muscular fatigue, discomfort, and increased risk of injury. Examples of awkward postures include how the workers bend low for their maintenance work or having the operators stretch uncomfortably to operate the machines.

REPETITIVE MOVEMENTS

- Many machines are designed to achieve industrial efficiency by breaking down manufacturing processes into simple steps that machines can carry out. While some steps can be fully automated, the requirement for man-machine interaction usually remains for key operating steps like loading of raw material, quality inspection and final assembly. These steps may require repetitive movement by the machine operator. These repetitive movements may become detrimental to workers' health leading to chronic musculoskeletal disorders. This usually happens when the same joints and muscle groups perform the same action often, quickly, and strenuously over an extended period without giving the body sufficient time to rest and recover.

8.4 FATIGUE

Fatigue is a state of tiredness leading to reduced mental and physical performance that can endanger workplace safety and workplace health. Long working hours and poorly planned shift work can result in employee fatigue, leading to reduced productivity. Fatigue can also lead to near-miss incidents, serious injuries, and even fatal accidents due to reduced concentration and alertness.

In general, fatigue can be caused by the following:

a) Long working hours without rest;
b) Intense and sustained physical work and mental effort;
c) Working during part of or all the natural time for sleep; and
d) Lack of rest and sleep

To reduce the endangerment and minimise the risk caused by the above hazards, fatigue needs to be managed i.e. risk assessment is necessary for the employer or occupier to conduct before work for the safety and health risk to the person operating the equipment as imposed in the WSH (Risk Management) Regulations, 2014. Where it is not reasonably practicable to eliminate the risk, the occupier and employer shall make reasonably practicable measures to minimize the risk and safe work procedures to control the risk and minimize the hazard.

9. SAFE USE OF MACHINES

Workers who operate machines must be trained, competent, and/or suitably supervised so that they do not put themselves or others at risk while at work.

Before starting an operation, it is important to:

a) Obtain the latest copy of the completed Risk Assessment (RA), understand the hazards posed by the machine and identify the control measures implemented.
b) Carry out pre-operation functionality checks on all machine safety devices (e.g., machine guards, presence-sensing devices, two-handed control devices, interlocking devices and emergency stop buttons).
c) Adhere to Safe Working Procedures (SWPs)
d) Put on the appropriate PPE such as safety glasses or goggles if there is a risk of materials being ejected during operation. Hearing protectors must be worn should there be excessive exposure to noise above 85 dB(A) over 8 hours while working at the machine.

9.1 TRAINING FOR THE OPERATOR

Employers need to ensure that workers are adequately trained and competent in machine operation and maintenance before assigning work. Training may include formal classroom training, on-the-job coaching, and specific work instructions to individuals or groups. All training should be properly documented (e.g., date of training, participant list and topics covered).

Training should be conducted:

- during orientation of new employees.
- periodically for existing employees.
- whenever new machines or processes are introduced; and
- when an employee is transferred to another department or job function.

Once workers have received training, they should be able to:

- follow SWPs and operate the machines safely.
- use PPE correctly.
- exercise due diligence to report accidents, incidents, near misses or any workplace hazards to their supervisors.
- carry out emergency response procedures; and
- participate in WSH management activities.

Retraining is necessary, when:

- new machines are installed, or modifications are made to existing machines;
- changes are made to SWPs; and
- RA forms are updated.

10. MAINTENANCE OF MACHINES

In general, machines must be regularly maintained for optimal performance. Regular maintenance is also necessary to prevent breakdowns and ensure that the machine remains safe for use. Machines must be maintained and repaired according to the manufacturer's specifications or, in the absence of such specifications, in accordance with a competent person's recommendations.

As with all work activities, a site-specific RA must be carried out before maintenance work is attempted.

10.1 MAINTENANCE PROGRAMME

An effective maintenance programme should be established for all machines and equipment used. This will help prevent accidents from happening due to machine or equipment failure.

A maintenance programme should include:

- a listing of all machines and equipment used within each worksite;
- inspection and maintenance schedules and records for each machine and equipment; and
- a system for employees to report any defective or damaged machine in the course of their work.

If the machine is not functioning properly, only trained and authorised personnel may be tasked to diagnose its problem. Replacement parts and devices recommended by the manufacturer should be used to maintain the integrity and continued safe use of the machine. The replacement parts need to be properly matched to the machine series, model, serial number and revision of the machine. If original replacement parts are not available, consult the manufacturer for recommendations on suitable alternatives.

10.2 TRAINING FOR MAINTENANCE WORKERS

Authorised personnel performing servicing and maintenance need to be trained to:

- Recognise hazardous energy sources and understand the magnitude of the energy source at hand;
- Identify and properly operate the applicable energy-isolating devices;
- Carry out the LOTO procedure; and
- Safely apply and remove lock-out devices.

Machine operators need to be trained to:

- Recognise when lock-out activities are in progress; and
- Understand the purpose of the energy lock-out and the importance of not tampering with the lock-out devices encountered at the workplace.

10.3 LOCK-OUT TAG-OUT PROCEDURE

All energy sources (whether electrical, mechanical, pneumatic, hydraulic or in any combination) must be securely isolated before any machine repair or maintenance is attempted. This is to ensure that the machine does not move or accidentally start up due to an unexpected release of an energy source. The steps necessary to isolate all forms of hazardous energy are termed the LOTO procedure.

11. CONTROL MEASURES OF MECHANICAL HAZARDS

There are three basic approaches to applying risk control measures for machines:

a) Risk control by inherently safe design measures;
b) Risk control by safeguarding and implementation of complementary protective measures; and
c) risk control by information for use.

11.1 RISK CONTROL BY INHERENTLY SAFE DESIGN MEASURES

Inherently safe design measures are the first and most important step in the risk control process. This is because protective measures inherent to the characteristics of the machine are more likely to be effective in risk reduction than a safeguard or protective measure (which can fail or be intentionally violated) or information for use (which may not be understood or closely adhered to by the machine operator).

Aspects of inherently safe design can be applied to the machine and/or the interaction between the machine and the operator at risk. Inherently safe design can be achieved through safer machine design and reducing the interaction between man and machine.

11.1.1 SAFER MACHINE DESIGN

The objective of inherently safe machine design is to avoid hazards or reduce the risk of exposure to hazards. This can be achieved via good machine design and intentional designing for safety:

1. AVOID SHARP EDGES, CORNERS AND PROTRUDING PARTS

Accessible parts of the machine should be designed with no sharp edges, sharp angles, rough surfaces, or any protruding parts likely to cause injury. The machine's preliminary design should also be reviewed to remove openings that can trap parts of the body or clothing. Sheet metal edges should be deburred, flanged or trimmed, and any open ends of tubes which can cause trapping should be capped.

2. AVOID CRUSHING, SHEARING AND ENTANGLEMENT POINTS

The relative location of mechanical parts should be taken into consideration to avoid any point(s) that can cause crushing, shearing or entanglement. This can be made possible by increasing the minimum gap between moving parts so that the part of the body under consideration (e.g., one's fingers) can safely move through the gap or reducing the gap so that no part of the body can enter it.

3. LIMIT THE ACTUATING FORCE

In some cases, the actuating force exerted by moving machine parts can be limited to reduce harm to the operator. By limiting the actuating force to a sufficiently low value, the impact of the force generated can be reduced to the

point where the mechanical hazard no longer exists. This can be achieved by limiting the mass and/or velocity of

4. DESIGN TO ELIMINATE THE NEED FOR PROTECTIVE MEASURES

This involves incorporating innovative features into the machine design so that work activities can be made inherently safe thus eliminating the need for a safeguard or protective device. Examples where the reliance on safeguards may be eliminated include:

- locating grease inlet points on the opposite side of a machine which has hot parts; and
- locating lubrication points away from parts of the machine which has moving parts.

5. CONSIDER MACHINE ERGONOMICS

Incorporating ergonomic principles in the man-machine interface by applying anthropometric (human body) measurements in machine design can help reduce exposure to ergonomic risks (e.g., leading to musculoskeletal disorders) and the likelihood of errors during machine use. The anthropometric measurements are important as they will influence, for example, the dimensions of the machine necessary for maintenance, routine work and comfortable access.

11.1.2 REDUCED MAN-MACHINE INTERACTION

Machines can be made safer once the requirement for man-machine interaction is reduced.

There are two key approaches to achieve this:

1. AUTOMATION

Automation can be accomplished, for example by industrial robots or automatic handling devices and transfer mechanisms. Through automation, the requirement for man-machine interaction during daily operations can be effectively reduced. It is important to understand that while automation can prevent accidents, the deployment of automated machines may create new dangers especially when equipment faults or operating problems occur. A thorough Risk Assessment (RA) should be undertaken to identify residual

hazards post-automation and suitable control measures implemented to control the risk (e.g., equipment safeguards, and safety interlock systems).

2. RELIABLE MACHINE COMPONENTS

Reliable components are, in general, parts that are well-made and of good quality. They can withstand stresses associated with machine operation for an extended period with a low probability of failure or malfunction. The increased reliability of the machine as a whole will significantly reduce the frequency of incidents requiring man-machine intervention (e.g., incidents requiring repair or overhaul), thereby reducing exposure to machine hazards which will, in turn, prevent accidents.

11.2 RISK CONTROL BY SAFEGUARDING AND IMPLEMENTATION OF COMPLEMENTARY PROTECTIVE MEASURES

11.2.1 MACHINE GUARDS

In cases where risk control by inherently safe design measures is not possible, the use of engineering controls (e.g., the use of machine guards and other physically implementable protective measures) becomes the next critical approach to risk reduction.

Machine guards are physical barriers that surround hazardous machine components and prevent operators from entering these areas. The guards provide partial coverage of the operation point while permitting little to no access. The guards are made with care for the environment in mind:

a) The intended uses of the machine.
b) The reasonably foreseeable incorrect use of the machines.
c) All voluntary and involuntary movements of the operator

It is important to note that the machine guards must be positioned in a manner that does not obstruct the operator's view and interfere with the normal operation of the machine.

To ensure that guarding is effective against the hazards, the employers must:

a) Ensure that the operators are well-trained to verify that the machine guards are functional and securely in place.
b) Schedule supervisors to conduct inspections periodically.

c) Assign engineers to verify that any new or modified operation is properly guarded before declaring usage.
d) Hold maintenance personnel responsible for ensuring machine guards are properly maintained and placed on a preventive maintenance programme.
e) Assign the safety manager or safety committee to audit the effectiveness of the machine guarding and resolve outstanding issues.
f) Encourage plant managers to show support and give recognition when audits show that machine guards are used properly and free from defects.

As part of the machine guarding programme, the operators will need to receive training on the various types of guards used and their applications. This will help the operators understand the basics of machine guarding and how it provides physical protection from machine hazards.

Machine guarding is required in dangerous moving parts in three basic areas:

POINT OF OPERATION	POWER TRANSMISSION	MOVING PARTS
1) Point where work is performed. 2) Cutting 3) Shaping 4) Boring 5) Forming	1) All components of the mechanical system that transmit energy to the machine part performing work 2) Flywheels 3) Pulleys 4) Belts 5) Couplings 6) Cams 7) Spindles 8) Chains 9) Cranks 10) Gears 11) Sprockets 12) Shafts 13) Rods	1) All parts of the machine move while the machine is working 2) Reciprocating 3) Rotating 4) Transverse 5) Feed mechanisms 6) Auxiliary parts

Table 1: Examples of where machine guarding is needed.

Fixed Guards

A fixed guard is a physical barrier that is permanently attached to a machine to prevent access to the danger zone from any direction. They are designed so that they are difficult or impossible to remove without the aid of a specific tool. Thus, this makes the fixed guards to be safer than other types of guards as they are harder to remove. In general, fixed guards are preferred due to their simplified installation and long-lasting. Thus, fixed guards are commonly used to cover power transmission units such as prime movers.

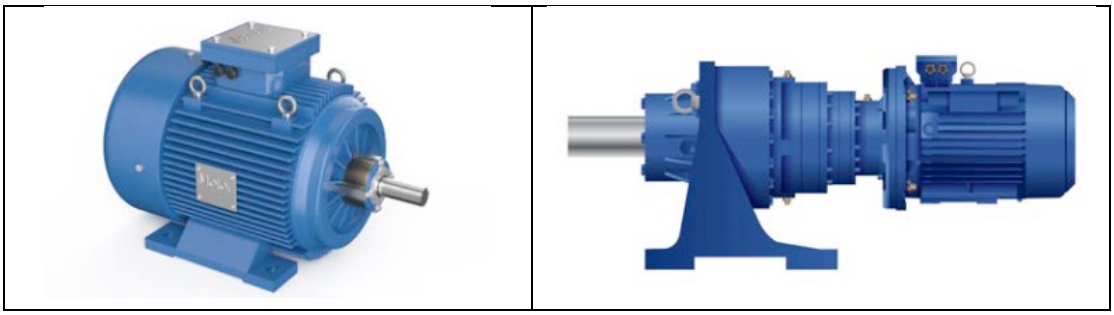

Figure 9: Example of a fixed guard of a motor shaft

(These photos have been taken from
Guide to Machine Safety - Safe Work Australia)

Adjustable Guards

An adjustable guard can be changed or rearranged to fit the size of the task at hand. A machine with adjustable guards can handle a wide range of material sizes while keeping users out of the danger zone. Any manual guard adjustment must be done by a qualified and trained individual.

Figure 10: Example of an adjustable guard

(These photos have been taken from
Guide to Machine Safety - Safe Work Australia)

Self-adjusting Guards

Until a workpiece is pushed into the point of operation and moves the guard, a self-adjusting guard protects the risk zone. Therefore, the work piece's movement determines the distance between the self-adjusting guard and the danger zone. The guard is pulled aside to give clearance as the operator moves the workpiece into the dangerous region so that it can be entered. The guard will automatically revert to its neutral and safe position after the work item has been removed.

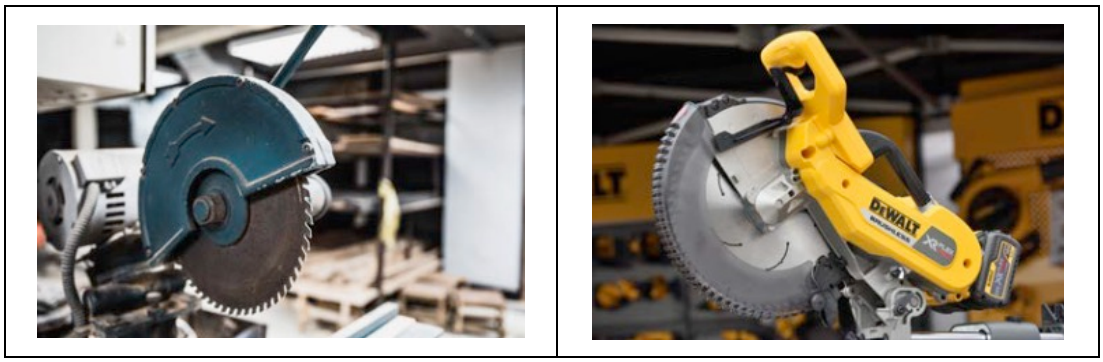

Figure 11: Example of a self-adjusting guard saw

(These photos have been taken from
Guide to Machine Safety - Safe Work Australia).

Interlocking Guards

When an interlocking guard is opened or pushed out of place, it shuts down or disengages the power to the machine. The switch or interlock will automatically stop the hazardous operation or motion after the interlocking guard has been disengaged. The interlocking guard must be put back in place before the machine may be manually restarted. If a spring interlocking device is used, ensure that the spring is discharged before interlocking back in place subsequently.

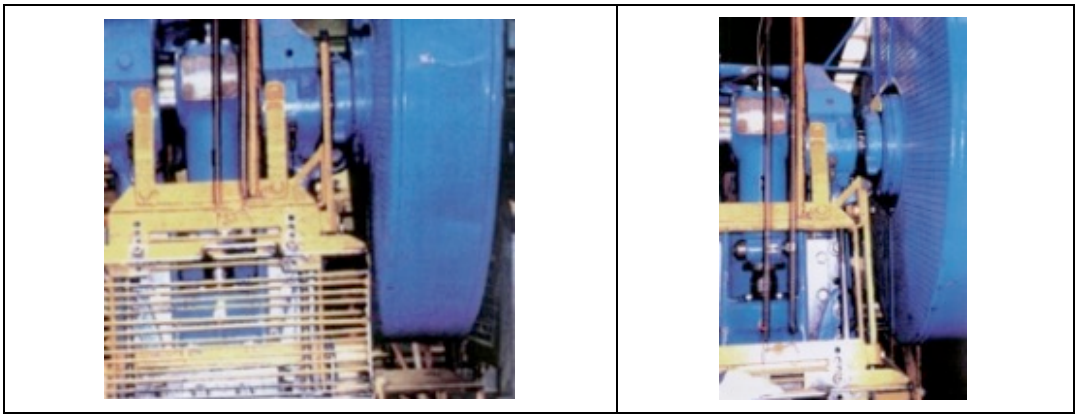

Figure 12: Example of an interlocked guard of a power press machine

(These photos have been taken from
Guide to Machine Safety - Safe Work Australia)

11.2.2 SENSOR SAFETY DEVICES

A presence-sensing device will not prevent access to the dangerous parts of the operation, but it can detect a person once any part of his or her body enters the identified danger area. When this happens, the machine can be automatically programmed to raise an alarm, reduce the speed of its moving parts, or be stopped immediately.

It is vital to note that the use of sensor devices alone is insufficient for physical protection caused by the hazards. Additional safeguards (e.g., suitable fixed barriers, or machine guards) may be used in combination with a presence sensing safety device to offer increased levels of protection. When installing a sensor device, careful positioning is required so that the sensors do not detect false or stray signals from other transmitting devices or equipment in the vicinity.

Safety Mats

Using pressure-sensitive safety mats is one of the simplest methods to protect the workers working around the hazardous machine. The safety mats are laid around the machine where the mats normally contain an open switch. When a weight is applied (usually a body) to the safety mat, this switch closes and then sends a signal to the machine, stopping immediately.

Figure 13: Example of a pressure mat

(This photo has been taken from WSH Guidelines on Safe Use of Machinery – WSH Council at Singapore)

Safety Light Curtain

The safety light curtain is connected to the control system of a machine so when the light of the machine is being cut off or broken (e.g., by the hand of the operator reaching the danger zone), the machine will not operate until the body part Is out of the sensing zone.

The response time of the safety light curtain should be shorter than the time part of the body reaches the hazard from the sensing zone.

Figure 14: Machine safety curtain installed

(This photo has been taken from WSH Guidelines on Safe Use of Machinery – WSH Council at Singapore)

Safety Laser Scanner

Laser scanners combine pulsed infrared laser and time-of-flight technology to precisely calculate the location of any detected person or object within a dangerous area. This location is then compared with the safety and warning zones defined in the device. If the person or object is present inside the warning zone, audible and visible signals can be triggered. If intrusion into the safety zone occurs, the scanner can be programmed to promptly send a stop signal to the hazardous machine.

The laser scanner can be deployed in stationary (mounted on a fixed object) or in mobile (mounted on a moving object) applications. The advantage of laser scanners is that they can safeguard all points within the perimeter of the danger area. The predefined danger area can be configured to protect the areas that are rectangular or circular in shape as well as areas that are irregularly shaped.

Figure 15: An example of a safety laser scanner

(This photo has been taken from WSH Guidelines on Safe Use of Machinery – WSH Council at Singapore)

Safety Camera

Safety camera systems are electro-sensitive protective devices that are based on three-dimensional image processing technology. As opposed to simple sensors, a safety camera system can continuously monitor a dangerous area and record or analyse detailed information on the entire area being monitored. The detection zone of the safety camera is typically divided into the warning and danger zones.

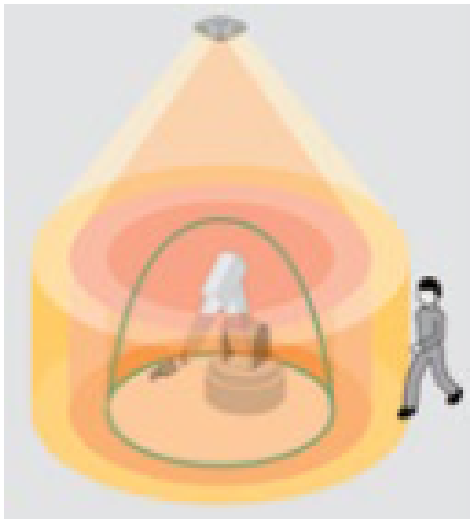

Figure 16: Example of a Safety Camera

(*This photo has been taken from WSH Guidelines on Safe Use of Machinery – WSH Council at Singapore)*

Two-handed Control Device

A two-handed control device requires the operator to use both hands to operate the machine. To prevent simultaneous one-handed operation, two-handed control buttons must be placed far away from the hazardous point of operation. If any of the control buttons are released, the machine comes to a complete stop.

While the use of the two-handed control device can protect the user of the operation, it does not provide any protection for the people surrounding the point of operation. Hence, the two-handed control device should be used together with the different types of machine guards.

Green switches need two hands to operate

Figure 17: An example of a two-handed control device

(This photo has been taken from Guide to Machine Safety - Safe Work Australia)

11.2.3 EMERGENCY STOP DEVICE

Emergency stop devices are made to be used in response to an accident or a dangerous circumstance. All sources of energy should be disconnected as part of a safety mechanism in such circumstances. Once the operator recognises the danger, the emergency stop devices enable the machine to stop at once simply by pressing or activation.

Every machine used in industrial machines or automation systems should be equipped with at least one emergency stop device. The emergency stop device should be located and mounted such that it is readily accessible by the operator in an emergency. In general, the emergency stop devices would need to be manually reset before the machine can be restarted. Such examples of emergency stop devices include the usual emergency push-stop button, emergency stop pull-cords, and emergency stop foot pedals. It is also important to note that every emergency stop device should be readily accessible to the operator.

Figure 18: Example of an emergency stop device

(This photo has been taken from WSH Guidelines on Safe Use of Machinery – WSH Council at Singapore)

11.2.4 WARNING DEVICE

Appropriate warning devices can be installed on machines to indicate that a predefined condition has been detected, or a hazardous situation exists. Warning signals may be audible, visual (flashing lights) or a combination of both. This can ensure that the workers in the vicinity are aware of the situation and affect the necessary remedy action or adopt a safe position away from the operated machine.

11.3 RISK CONTROL BY INFORMATION FOR USE

If risk control by safeguarding and implementation of complementary protective measures is insufficient to reduce the risk to the desired safe level, further risk control can be achieved through the provision of information for use (e.g., via warning signs and SWPs). Such information will serve to alert machine operators of the residual risks and administrative control measures put in place to keep the work activity safe.

11.3.1 SAFE WORKING PROCEDURE (SWP)

A SWP is a working risk control document that gives out the safest and most efficient way to perform a certain work activity. An SWP generally lists the hazards involved in performing a work activity, the PPE required, and the operating steps necessary to complete the activity without incident.

A good SWP document should contain detailed information on:

1. Hazards of the machines, equipment and material used.
2. Inherent risks associated with the work activity.
3. Operating steps or a sequence to carry out work safely.
4. Risk control measures to be implemented and PPE to be used.
5. Residual risks and action to be taken to address the risk while carrying out the work activity.

11.3.2 LOCK OUT TAG OUT (LOTO)

A LOTO procedure ensures that all the hazardous energy sources (whether electrical, mechanical, pneumatic, or hydraulic) of a machine are isolated, disconnected or discharged before commencing work like maintenance, repair and installation of the machine. This is to prevent the machine from being inadvertently activated or energized while the work activity is in progress.

Before doing the LOTO procedures, ensure that permits are obtained if it is applicable.
Below are five recommended steps for effective LOTO for hazardous machines.

a) Announce the shutdown
b) Shutting down the machine
c) Disconnecting all energy sources
d) Apply lock-out and Tagout
e) Verifying isolation and lock-out

Figure 19: A lock-out tag

(This photo has been taken from WSH Guidelines on Safe Use of Machinery – WSH Council at Singapore)

11.3.3 SAFETY SIGNS

Safety signs are important hazard communication tools to alert or remind workers of workplace hazards and safety precautions to take at specific work areas, especially when working with a hazardous machine. The safety signs should contain simple graphics or words that can be easily understood by the public. It is also important to keep the signs in good condition so that they can be seen from a distance. The safety signs are generally classified according to their function.

Mandatory Action

i. Signs (blue circle signs) indicate action that must be carried out in specific work areas.

Prohibition

ii. Signs (with the red circular band and a red diagonal bar) indicate an action or activity that is not permitted.

Warning

iii. Signs (yellow signs with black triangle band) alert workers of a hazard or hazardous condition

Fire Safety

iv. Signs (in red with white lettering) indicate the location of fire alarms and fire protection equipment.

Safe condition

v. Signs (in green with white lettering) to indicate the location of emergency-related facilities such as exits, first and safety equipment.

Figure 20: examples of Warning signs

(This photo has been taken from WSH Guidelines on Safe Use of Machinery – WSH Council at Singapore)

11.4 PERSONAL PROTECTIVE EQUIPMENT (PPE)

PPE is equipment worn to minimise exposure to hazards. PPE is found at the bottom of the hierarchy of hazard controls because it is designed to protect the employee once the hazard comes into contact with them, not prevent the hazard from happening. Personal protective equipment should be considered the last resort for employers and their employees and should be an aid used along with existing hazard protection processes to protect an employee when hazards are not already well controlled.

PPE as a minimum must include hand gloves, safety glasses, hearing protection, hard hats, safety boots and respirators (used only in toxic / chemical hazard zones). When employees use the PPE, employers should implement a PPE program. While elements of the PPE program depend on the work process and the identified PPE, the program should address:

a) Workplace hazards assessment
b) PPE selection and use
c) Inspection and replacement of damaged or worn-out PPE
d) Employee training
e) Program monitoring for continued effectiveness

Employers should not rely on PPE alone to control the hazards when other effective control options are available. PPE might seem to be less expensive than other controls but can be costly over time. This is especially true when used for multiple workers daily.

When the other controls are unable to reduce the hazardous exposure to safe levels, the employers must provide PPE. This includes:

a) While other controls are under development
b) The other controls could not reduce the hazardous exposure.
c) When PPE is the only control option available

Administrative controls and PPE require significant effort by workers and their supervisors. They are useful when employers are in the process of implementing other control methods from the hierarchy. Additionally, administrative controls and PPE are often applied to existing processes where hazards are not well controlled.

Training and evaluation can help to ensure that the selected controls are successful. The employers should correctly train the workers and supervisors on how to use the controls. Workers and their supervisors should evaluate controls regularly. Regular evaluation can check whether the controls are effective in reducing the workers'

exposures and identify potential improvements. PPE includes items of protective clothing such as coveralls, covered non-slip shoes, heat-resistant gloves, and protective items such as safety eyewear and use of respirators. PPE offers protection from workplace hazards only if it is in good condition, properly selected for the work activity and correctly fitted to the user.

Workers may be exposed to falling or flying objects, splashing fluids, harmful dust, fumes, mists, vapours, or gases when working with a machine. It is important to provide workers with suitable PPE and information on how to use PPE correctly to ensure effective protection from the hazards present in the workplace.

As the use of PPE does not eliminate or reduce the hazard, the PPE user is likely to be exposed to the hazard should the PPE fail. Given that PPE should be considered the last level of protection when all other control measures are not feasible, a PPE programme is recommended to ensure that workers are well-protected when PPE is used.

The key elements of a comprehensive PPE programme include:

1. PPE selection
2. PPE fitting
3. PPE maintenance and storage; and
4. PPE user education and training.

PPE Selection

All activities involving the use of machines must be thoroughly evaluated by RA so that suitable PPE can be selected specifically for each activity. Once the hazards are identified, a useful approach is to think from “head to toe” about the necessary protection needed to prevent workers from injury.

PPE Fitting

For effective protection, PPE (e.g. safety shoes, coveralls etc.) must be correctly fitted to its user.

PPE maintenance and storage

To keep PPE in good condition and ready for use, PPE must be properly stored to prevent material deterioration. PPE should also be subjected to regular maintenance and checks before use. Finally, PPE needs to be replaced periodically, depending on the frequency of use, and lifespan of its material.

PPE user education and training

As part of the PPE program, users need to receive training on the proper selection of PPE, the choice of appropriate material and the correct method for its use.

Hand Protection

The right use of hand gloves is important to protect workers from physical and chemical hazards when using machines. The table below denotes the list of common types of gloves.

TYPE OF GLOVES	APPLICATION
LEATHER GLOVES 	Used for general protection against mechanical hazards such as abrasion, cuts and punctures.
CUT-RESISTANT GLOVES 	Used when handling sharp or serrated objects.
CHEMICAL-RESISTANT GLOVES 	Used for protection against chemical hazards such as acids, alkalis, solvents, fats and oils.
HEAT-RESISTANT GLOVES 	Used in activities where there are high temperatures, such as hot work, forging and vulcanising applications, handling of hot castings and smelting works.

INSULATED GLOVES 	Used for protection against electric shock or electrocution.
CRYOGENIC GLOVES 	Used for handling ultra-cold materials and containers, such as liquid nitrogen.

Table 2: Examples of different types of gloves.

Eye and Face Protection

When using a machine, examples of eye and face protection to protect one against material ejecting from the machine (e.g., metal or wood dust, sparks, and chemicals) include safety glasses, safety goggles and face shields.

In general, safety goggles offer greater protection than safety glasses. A face shield should be used in conjunction with a pair of safety goggles whenever a high probability of eye and face injury exists. Note that ordinary prescription spectacles do not provide adequate protection against eye injury.

Head Protection

In manufacturing environments where there is a risk of objects falling (e.g., from equipment installed overhead), or in areas where one can walk into hard objects, the use of a safety helmet is essential for basic protection against head injury. A helmet will reduce the impact experienced by its user when an object falls or hits his or her head. For manufacturing environments, the use of a safety helmet is necessary when working with overhead-mounted equipment like a travelling crane.

Many accessories can be fitted onto a safety helmet to make it appropriate for different work environments. For example, a chin strap may be attached to keep the helmet in place, a face shield may be attached to protect the user from any materials ejected from a machine, earmuffs may be attached to protect one's hearing in a noisy environment, and a headlamp may be attached for use in a dim working environment. When adding helmet accessories, it is important to ensure that the attachment is

compatible with the specific helmet. The use of the original manufacturer's accessories is recommended.

Hearing Protection

Many machines generate noise during operation. As a general guide to the use of hearing protectors, earplugs or earmuffs are used when the noise exposure is between 85 to 100 dB(A). Both earplugs and earmuffs should be used together for noise exposure exceeding 100 dB(A)

For effective noise reduction, at least 75% of the earplug should be inserted into the ear canal.

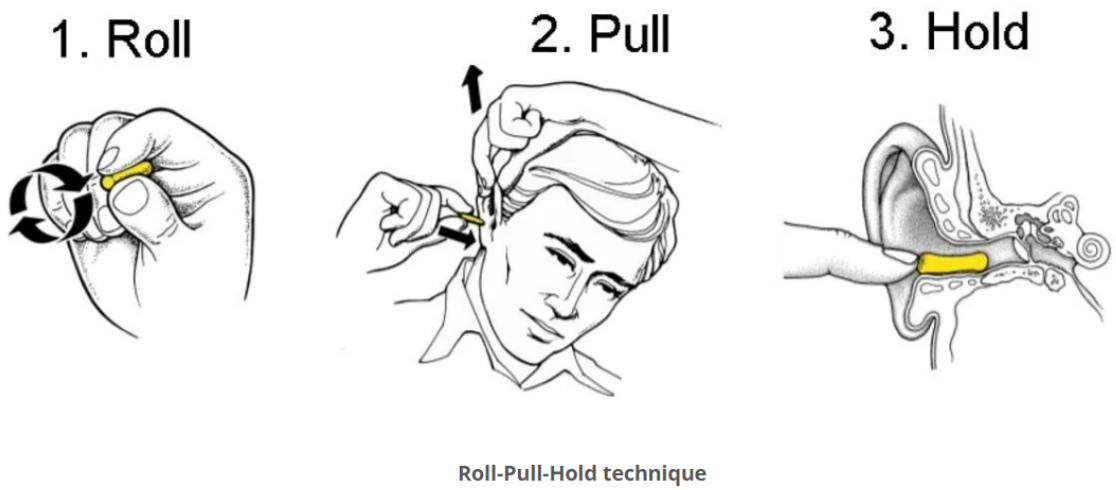

Figure 21: illustrated photos show how to fit ear plug

(*This photo has been taken from https://hsseworld.com)*

Respiratory Protection

Some machines generate harmful dust, fumes, vapours or gases during operation. In such cases, respirators are needed to protect workers from exposure via inhalation.

There are two basic types of respirators:

- air-purifying respirators (used only when oxygen is abundant in the work environment); and
- air-supplied respirators (typically used in oxygen-deficient environments).

The correct type of respirator should be selected based on the nature of the work environment and the hazards present in the workplace. Respirators need to be properly maintained and cleaned to retain their effectiveness. Respirator fit testing should be conducted to ensure adequate protection when in use.

Foot Protection

Safety footwear (e.g., safety boots) is designed to protect the feet from injury. Safety features include protective reinforcement in the toes area (via a steel toe cap) to protect the foot from falling objects (e.g., when a worker loses his or her grip while carrying a heavy load) or compression (e.g. when a worker's foot gets rolled over by a moving machine or vehicle), and a steel mid-sole plate to protect against punctures (e.g., a stray nail) from below. Safety shoes need to have antistatic properties and be durable, water resistant, hot or cold resistant, slip resistant, cut resistant, and electric shock resistant.

To ensure optimum performance, safety footwear should be checked for wear and tear at reasonable intervals. Ideally, safety footwear should be subjected to a quick visual inspection before each use. This includes checking for cuts, cracks or holes, separation of boot material, and broken buckles or laces. The soles of the boot, in particular, should be checked for pieces of metal, wood or other embedded objects that could affect the integrity or performance of the sole.

12. CONTROL OF NON- MECHANICAL HAZARDS

12.1 NOISE HAZARDS

a) Initially during the purchase of machines, specify and request a low-noise machine.
b) Replace noisy machines with less noisy ones.
c) Relocate noisy machines and processes to a lesser-occupied or non-occupied area of the workplace.
d) Locate noise sources away from hard walls or corners.
e) Construct suitable noise enclosures or barriers to isolate the source of noise and reduce noise emission.
f) Minimize the number of noisy machines running at any one time.
g) Provide workers with hearing protectors such as earmuffs or earplugs and ensure that they are properly used to reduce noise.

12.2 HEAT-RELATED HAZARDS

a) Insulate all hot machine surfaces whenever possible.
b) Install warning signs and labels to alert workers of the presence of a hot surface.
c) Provide workers with heat-resistant gloves when they need to perform work involving hot machines.
d) Improve the ventilation of the work area.

e) Ensure that workers get sufficient rest and drink enough water to stay hydrated throughout the work activity. Rotate job function among workers so that it minimizes exertion and controls their exposure to heat.
f) Workers should be aware that the use of certain PPE can increase the risk of heat-related illness (e.g., certain types of respirators and impermeable clothing).
g) Thermally conditioned clothing may be used for work in extremely hot conditions.
h) Heat Stress Monitor (HSM) is an essential tool for occupational and environmental health and safety (OEHS) professionals to measure radiant temperature, The HSM has applications in foundries, agriculture, offshore drilling operations, food industry, engineering, sports, and industry.

12.3 ELECTRICAL HAZARDS

a) Use only power sockets, plugs and cables that meet the required safety standards.
b) Conduct visual inspections on electrical machines before starting daily operations. Any electrical plugs, cords and wires found damaged or exposed should not be used.
c) Ensure that electrical machines are properly grounded.
d) Engage only electrical workers who are competent to carry out work.
e) Establish LOTO procedures for any work involving the repair and maintenance of electrical machines.
f) Do not clean electrical machines with flammable solvents.
g) Do not overload electrical power points.
h) Ensure electrical circuits are protected by suitably rated residual current devices.
i) Keep power cords away from heat, water, and oil.
j) Always pull the electrical plug, not the cord.
k) Switch off electrical devices before maintenance work. Isolate the device, and then test for discharge and see if it is connected to the earth before doing maintenance.

12.4 CHEMICAL HAZARDS

a) Eliminate or substitute hazardous chemicals wherever possible.
b) Install enclosed splash guards to protect workers from splashing due to machine operation.
c) Minimize the extent of splashing and mist generation by controlling the volume and delivery rate of the machining fluid to the cutting tool.
d) Develop SWPs for any work involving hazardous chemicals.
e) Safety Data Sheet (SDS) should be properly read and understood for emergency preparedness.
f) Install safety signage to warn machine users of the presence of a chemical hazard.

g) Ensure that the work area is sufficiently ventilated. The use of local exhaust ventilation (e.g., a fume extraction chamber) is recommended for any machine work where chemical mist, vapours and/ or aerosols are emitted.
h) Provide workers with appropriate PPE for the task, for example, chemical-resistant aprons and gloves, safety goggles or face shields, and respirators.
i) Train workers to keep the inside of the gloves clean when they are putting or taking them off.
j) Provide hand washing facilities and encourage workers to wash their hands regularly, especially before eating or drinking. Advise workers to pay particular attention to washing the skin under rings and watch straps when they are washing their hands.
k) Provide laundry service for company-issued work attire so that workers do not bring contaminated clothing home.
l) The first 10 to 15 seconds after exposure to a hazardous product, especially a corrosive product, are critical. Delaying treatment, even for a few seconds, may contribute to a serious injury. Emergency showers and eyewash stations provide on-the-spot decontamination. They allow workers to flush away hazardous products that can cause injury.

12.5 ERGONOMIC FACTORS

a) Reposition worker or location of work to avoid awkward posture.
b) Redesign work activities that require workers to reach over their shoulders or below their knees.
c) Ensure that new machines are positioned within easy reach for all workers, including maintenance staff.
d) Locate tools within easy reach.
e) Encourage employees to do simple stretching exercises at their workstations.
f) Automate repetitive tasks wherever possible.
g) Plan work schedules so that workers can take regular breaks (breaks can be short but regular).
h) Practice job rotation. This can include rotating workers through different work activities during their shifts to reduce the extent and duration required for repetitive movement.

12.6 FATIGUE

a) Schedule complex tasks to be performed only during the day.
b) Plan shift schedules ahead of time and communicate them to workers.
c) Limit shift work to not more than 12 hours including overtime.
d) Keep night shift work to a minimum.
e) Ensure that there is sufficient recovery time between shifts.

f) Encourage employees to take scheduled breaks to relieve fatigue.
g) Provide facilities for breaks such as pantry and shower facilities.
h) Provide after-work transportation for employees working long or night shifts.
i) Introduce shift rotation.
j) Develop a policy that specifically addresses and sets limits on working hours, overtime, and shift-swapping, that safeguards against fatigue.

13. REFERENCES

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2. Workplace Safety and Health (General Provisions) Regulations, 2014
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END